Technical Note

Air Quality Analysis of the Enhanced Oil Recovery/Central Compressor Plant Engineering Refinement to the Prudhoe Bay Unit

December 9, 1983

Submitted to:

U.S. Environmental Protection Agency
Region X, and
Alaska Department of
Environmental Conservation

Submitted by:

Prudhoe Bay Unit Owners

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AIR QUALITY ANALYSIS OF THE ENHANCED OIL RECOVERY/ CENTRAL COMPRESSOR PLANT ENGINEERING REFINEMENT TO THE PRUDHOE BAY UNIT

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EXECUTIVE SUMMARY

The Prudhoe Bay Unit Owners are proposing a modification to the source inventory for the Prudhoe Bay Unit (PBU) to reflect current engineering design refinements proposed for the PBU. The proposed PBU engineering design refinements indicate a need for 270 MM Btu/hr of heater capacity and 252 MHP of turbine capacity near the Central Compressor Plant (CCP). This requirement for Enhanced Oil Recovery (EOR/CCP) heater and turbine capacity near the CCP will be balanced by deletions of previously permitted, but currently non-essential, heater and turbine capacity in the PBU.

Also, as part of this proposed EOR/CCP Engineering Refinement to the PBU, previously permitted 750 MM Btu/hr of heater capacity at the Seawater Treatment Plant will be reduced to 720 MM Btu/hr of heater capacity. Therefore, the total heater and turbine capacity proposed for the PBU will decrease due to the proposed EOR/CCP Engineering Refinement. As a result of these capacity decreases, pollutant emissions will also decrease for the PBU.

The purpose of this document is to request an administrative change to the Prevention of Significant Deterioration (PSD) permits issued for the PBU to incorporate the proposed EOR/CCP Engineering Refinement to the PBU. To support this request an air quality impact analysis was performed to assess any air quality impact changes resulting from the proposed EOR/CCP Engineering Refinement.

The maximum predicted impacts for nitrogen dioxide (NO_2) decreased for the annual averaging period. Changes in the maximum predicted total suspended particulate matter (TSP) impacts for the annual and 24-hour averaging periods are below

the respective significant impact levels. Sulfur dioxide (SO_2) concentrations for the annual, 24-hour, and 3-hour averaging times did not exceed the corresponding significance levels for the original PBU source inventory or the proposed EOR/CCP Refinement to the PBU source inventory.

Emissions of total hydrocarbons (THC) and carbon monoxide (CO) will decrease for the EOR/CCP Refinement to the PBU. Since previous analyses for the impacts of ozone (O_3), based on THC emissions, and CO were extremely conservative, previously predicted impacts of O_3 and CO remain valid and were not repeated.

The predicted air quality impacts due to the proposed EOR/CCP Engineering Refinement to the PBU will not approach any National Ambient Air Quality Standard or PSD Increment.

1.0 INTRODUCTION

The Prudhoe Bay Unit Owners have submitted four Prevention of Significant Deterioration (PSD) permit applications to the Environmental Protection Agency (EPA) Region X to construct oil and gas production facilities in the Prudhoe Bay Unit (PBU) Oil Field. The application titles, submittal date, and PSD permit numbers are shown in Table 1-1.

TABLE 1-1. PRUDHOE BAY UNIT PSD PERMIT APPLICATIONS

Title	Date	Permit Number
PSD Permit Application for Construction of Additional Facilities at the Prudhoe Bay Oil Field, Prudhoe Bay, Alaska (PSD-I)	8/2/78	PSD-X79-05
PSD Permit Application for the Prudhoe Bay Unit Produced Water Injection, Low Pressure Separation and Artificial Lift Projects (PSD-II)	9/28/79	PSD-X80-09
PSD Permit Application for the Prudhoe Bay Unit Waterflood Project (PSD-III)	9/28/79	PSD-X81-01
PSD Permit Application for New Sources to be Added to Existing and Previously Permitted Facilities in the Prudhoe Bay Unit (PSD-IV)	1/30/81	PSD-X81-13

Engineering design for each of these projects has progressed since the time of the original submittals. Present design considerations indicate a need for a modification of the previously permitted heater and turbine capacity in the PBU. These proposed heater and turbine capacity refinements to the

PBU source inventory will result in an overall decrease in permitted heater and turbine capacity for the PBU. Pollutant emissions in the PBU will also decrease as a result of the proposed Enhanced Oil Recovery/Central Compressor Plant (EOR/CCP) Engineering Refinement to the PBU.

This technical note was prepared to assess the potential changes in air quality impacts due to the EOR/CCP Engineering Refinement. To be consistent with the air quality analyses performed for previous PSD permit applications the air quality analysis performed for the EOR/CCP Engineering Refinement to the PBU will follow the methods described in PSD IV.

2.0 PROPOSED HEATER AND TURBINE CAPACITY REFINEMENTS TO THE PRUDHOE BAY UNIT

The proposed EOR/CCP Engineering Refinement to the PBU source inventory involves an additional 270 MM Btu/hr of heater capacity and 252 MHP of additional turbine capacity located at the proposed Enhanced Oil Recovery facility and the CCP. To balance these proposed heater and turbine capacity changes, previously permitted, but currently non-essential, heater and turbine capacity in the PBU will be deleted. Heater capacity deletions totaling 276 MM Btu/hr will be obtained from Flow Stations 1 and 3 and the CCP. Turbine capacity of 259.8 MHP will be deleted from FS-1, FS-2, Seawater Treatment Plant (SWT), Injection Plant East (IPE), and Gathering Centers 2 and 3 (GC-2, GC-3).

Also, as a part of the EOR/CCP Engineering Refinement to the PBU, the previously permitted 750 MM Btu/hr of heater capacity at the SWT will be reduced to 720 MM Btu/hr of heater capacity. This reduction in heater capacity will be accomplished by changing the individual heater capacities proposed for the SWT. Previously permitted heater capacity for the SWT totaled 750 MM Btu/hr and was composed of 3-110 MM Btu/hr, 3-100 MM Btu/hr, and 2-60 MM Btu/hr heaters. The currently proposed EOR/CCP Engineering Refinement proposes a total SWT heater capacity of 720 MM Btu/hr composed of 6-120 MM Btu/hr heaters. A summary of the proposed heater and turbine capacity changes is shown in Table 2-1. Permit tracking reports are shown in Appendix A.

For turbine capacity the Unit Owners desire to retain design flexibility in the installation of actual turbines in the PBU. Total turbine capacity is therefore permitted rather than specific units. The present proposed modification to the PBU requires 252 MHP of turbine capacity near the CCP. At this time

TABLE 2-1. COMPARISON OF CURRENTLY PERMITTED AND PROPOSED EOR/CCP ENGINEERING REFINEMENT CAPACITIES AND EMISSIONS IN THE PRUDHOE BAY UNIT

Status	Facility	Permit	UTM Coordinates Easting (km)	UTM Coordinates Northing (km)	Equivalent Number of Units[1]	Modeled Equivalent Unit Capacity MHP	Modeled Equivalent Unit Capacity MMBTU/HR	Emissions Rate (ton/year) NO_x	Emissions Rate (ton/year) PM	Emissions Rate (ton/year) SO_2
Currently Permitted Source Deletions	GC-2	PSD II	430.050	7801.800	3	26.6	-	2060.3	52.10	12.57
	GC-3	PSD IV	436.800	7798.550	1	60	-	1601.8	39.25	9.45
	FS-1	PSD IV	445.900	7795.100	1	-	125	104.9	5.90	1.98
	FS-1	PSD IV	446.100	7795.300	1	36	-	961.0	23.62	5.66
	FS-2	PSD II	449.550	7795.000	1	36	-	929.4	21.26	5.70
	FS-3	PSD IV	440.650	7795.600	1	-	125	104.9	5.90	1.98
	IPE	PSD III	445.500	7795.000	1	16	-	412.6	10.00	2.54
	CCP	PSD II	443.700	7802.203	1	-	26	21.9	1.04	0.42
	SWT	PSD III	443.000	7810.133	3,3	-	110,100	523.8	29.87	10.00
	SWT	PSD III	443.000	7810.133	2	-	60	99.0	5.56	1.91
	SWT	PSD IV	443.000	7810.100	8	4.0	-	854.39	20.84	5.04
	Total					259.8	1026	7673.79	215.34	57.25
Proposed EOR/CCP Engineering Refinement Sources	SWT	Proposed	442.840	7812.340	6	-	120	607.4	34.52	11.39
	EOR	PBU	443.370	7802.100	2	36	-	1922.0	47.23	11.32
	EOR	Amendment	443.430	7802.160	2	36	-	1922.0	47.23	11.32
	CCP	"	443.660	7802.160	3	36	-	2883.0	70.85	16.98
	EOR	"	443.370	7802.240	3	-	90	241.7	13.89	4.52
	Total					252.0	990	7576.1	213.72	55.53
	Net Change					(7.8)	(36.0)	(97.69)	(1.62)	(1.72)

[1] In order to retain production flexibility, the Unit Owners have permitted a total turbine capacity rather than specific units. Conservative modeling methods have been employed in that the stack parameters of the smallest turbine consistent with intended turbine use were modeled. The number of units is therefore the equivalent modeled number of a specific size turbine needed to produce the total permitted capacity.

the total turbine capacity proposed for the EOR/CCP will be attained by seven 36 MHP turbines. The turbine capacity to be deleted from the PBU source inventory is 259.8 MHP. Individual turbines to be deleted range in size from 4 MHP to 60 MHP.

The proposed EOR/CCP Engineering Refinement to the PBU will result in a net decrease in PBU permitted capacity and emissions. Nitrogen oxide emissions will decrease by 97.69 TPY. Particulate matter emissions will decrease by 1.62 TPY. Sulfur dioxide emissions will decrease by 1.72 TPY.

Potential emissions for the PBU sources were calculated using the PBU fuel gas composition, the applicable New Source Performance Standard (NSPS), or the AP-42 emission factor as appropriate. Sample emission calculations are presented in Appendix B of PSD-IV.

3.0 AIR QUALITY IMPACT ANALYSIS

Air quality impact analyses were performed for the proposed EOR/CCP Engineering Refinement for the PBU. Revised pollutant impacts were analyzed for emissions of NO_x, PM, and SO_2. The change in predicted air quality impacts due to the proposed EOR/CCP Refinement is less than 1 $\mu g/m^3$ and there is little change from the results reported in PSD-IV and subsequent correspondence. Therefore, the proposed EOR/CCP Engineering Refinement does not approach any National Ambient Air Quality Standard (NAAQS) or PSD increment. Emissions of THC and CO decrease due to the EOR/CCP Engineering Refinement. Previous estimation of O_3 and CO impacts were extremely conservative. Therefore, no analysis for carbon monoxide (CO) and ozone (O_3) impacts were needed beyond those in PSD-IV. This section describes the modeling methodology and predicted impacts of emissions of nitrogen dioxide (NO_2), total suspended particulate matter (TSP), and SO_2 resulting from the proposed EOR/CCP Engineering Refinement for the PBU.

3.1 Analysis Methodology

The atmospheric dispersion modeling techniques described in PSD-IV were used in the analysis described in this technical note. Annual modeling was performed using the Industrial Source Complex-Long-Term (ISCLT) dispersion model. Short-term modeling was performed using the ISC-Short-Term (ISCST) dispersion model. Meteorological data used in the modeling was obtained from the Prudhoe Bay area PSD monitoring network as described in PSD-IV.

The annual air quality analysis for PSD-IV indicated that the maximum pollutant impacts in the Prudhoe Bay Oil Field occurred 250 meters downwind (west) of Flow Station 1 (FS-1). Additional "hot spots" occurred 250 meters west of GC-1 and GC-2.

For this proposed EOR/CCP Engineering Refinement, impacts were predicted around the maximum impact receptors identified during the analysis for PSD-IV. Receptors were also located on a 8 x 5 grid with 100 meter spacing surrounding the CCP.

The NO_2 impacts were determined from the predicted NO_x concentration using the ozone-limiting method. A description of the ozone limiting method is presented in PSD-IV. Briefly, the technique limits the formation of NO_2 to two processes. First, ten percent of NO_x emissions are assumed to be directly emitted as NO_2 due to in-stack conversion. Second, the conversion of the remaining NO_x to NO_2 is limited by the concentration of O_3 occurring in the ambient air.

The annual impacts of SO_2 and TSP from the proposed modification were predicted by modeling the same receptors and facilities in the PBU as were modeled to predict NO_2 impacts. The annual SO_2 impacts were not significant and therefore no further SO_2 analysis was required.

The screening analysis for short-term impacts of TSP and SO_2 from the proposed modification were predicted by modeling near FS-1 and the CCP. The FS-1 facility was modeled because the maximum predicted 24-hour TSP concentrations due to the original PBU inventory occurred close to this facility. The CCP was modeled because the largest heater and turbine capacity changes due to the EOR/CCP Engineering Refinement occur at or near the CCP.

The SO_2 24-hour and 3-hour impacts were below significance levels for all the proposed EOR/CCP sources and the original PBU source inventory. Therefore, no refined short-term SO_2 modeling of the proposed modification was performed for this analysis. Receptors for the screening analysis were located on a polar grid at distances of 250 meters, 500 meters and 750 meters from the facilities along radials 20 degrees apart. In the refined analysis, the five unique worst-case days determined from the FS-1 and CCP facility screening runs plus the five unique worst-case days identified in the PSD IV permit application air quality analysis were modeled with a rectangular grid and 100 meter receptor spacing. The days modeled were Days 272, 277, 257, 298, 359, 350, 340, and 273. Day 272 produced the highest 24-hour TSP concentration.

Emissions of THC and CO will decrease for the EOR/CCP Refinement to the PBU. Conservative modeling of O_3 and CO concentrations was performed in PSD IV assuming that all sources were colocated. Concentrations of CO were predicted to be below the significance levels in PSD IV. Therefore, no additional CO analysis was required. Source location is not important in determining O_3 impacts due to THC emissions. Thus, no additional O_3 analysis was required.

3.2 Air Quality Impacts

The maximum predicted annual NO_2 concentrations due to the proposed EOR/CCP modifications to the PBU are presented in Table 3-1. The maximum annual NO_2 concentration in the PBU decreased from the level reported in PSD IV. This maximum of 62.3 $\mu g/m^3$ occurred downwind of the CCP.

TABLE 3-1. MAXIMUM PREDICTED NO_2 CONCENTRATIONS PREVIOUSLY REPORTED IN COMPARISON TO THE MAXIMUM PREDICTED NO_2 CONCENTRATION AS A RESULT OF THE EOR/CCP REFINEMENT TO THE PBU

	Previously Reported Maximum Impacts ($\mu g/m^3$) in the PBU	Maximum Impacts ($\mu g/m^3$) Due to the EOR/CCP Refinement to the PBU
Monitored NO_2 Background	2.0	2.0
All Existing and Previously Permitted Sources	11.5	11.3
Ozone Limited NO_2	49.0	49.0
Maximum NO_2 Annual Impact	62.5	62.3*

*The modeled NO_2 at the same location of the previously reported NO_2 maximum concentration is 62.2 $\mu g/m^3$.

The predicted maximum annual TSP concentration and maximum annual increment consumption in the Prudhoe Bay Unit did increase as a result of the proposed EOR/CCP modification to the PBU (Tables 3-2 and 3-3). However, the increase in annual TSP concentrations and increment consumption was less than the 1 $\mu g/m^3$ annual significance level. The predicted 24-hour TSP concentration did not change as a result of the proposed EOR/CCP Engineering Refinement. The predicted 24-hour TSP increment consumption did increase as a result of the modifications to the PBU. However, an increase in increment consumption of 0.2 $\mu g/m^3$ is insignificant compared to the 24-hour significance level of 5 $\mu g/m^3$. Therefore the proposed EOR/CCP Engineering Refinement to the PBU will not result in significant annual and 24-hour TSP impacts.

TABLE 3-2. MAXIMUM PREDICTED ANNUAL TSP CONCENTRATIONS PREVIOUSLY REPORTED AND DUE TO THE EOR/CCP REFINEMENT TO THE PBU

	Maximum Impact Based on the Original PBU Inventory ($\mu g/m^3$)	Maximum Impact Due to the Proposed EOR/CCP Refinement to the PBU ($\mu g/m^3$)
Existing Sources	0.7	0.1
Maximum TSP Annual Increment Consumption	1.8	2.6
Maximum TSP Annual Impact	2.5*	2.7
Allowable Annual Class II Increment	19	19
Annual NAAQS	75	75

*TSP value not previously reported because the CCP was outside the significant impact area of sources added to the PBU.

TABLE 3-3. MAXIMUM PREDICTED 24-HOUR TSP CONCENTRATIONS PREVIOUSLY REPORTED AND DUE TO THE EOR/CCP REFINEMENT TO THE PBU

	Maximum Impact Based on the Original PBU Inventory ($\mu g/m^3$)	Maximum Impact Due to the Proposed EOR/CCP Refinement to the PBU ($\mu g/m^3$)
Existing Sources	40.5	40.5
Permitted and Proposed Sources	2.2	2.2
Maximum TSP 24-Hour Impact	42.7*	42.7
Primary 24-Hour NAAQS	260	260
Secondary 24-Hour NAAQS	150	150
Maximum TSP 24-Hour Increment Consumption	21.0	21.2
Allowable 24-Hour Class II Increment	37	37

*TSP value not previously reported because the CCP was outside the significant impact area of sources added to the PBU.

APPENDIX A

PERMIT TRACKING REPORTS

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PSD Permit Tracking Report

Permitted

Location	PSD Permit	Turbines Qty	Turbines Size	Heaters Qty	Heaters Size	Swap 1 Qty	Swap 1 Size	Swap IV Qty	Swap IV Size
FS-2	PSD I	2	25,000			-2T	25,000		
	PSD II	~~4~~	36,000	1	100,000			-1T	36,000
		2	5,000						
	PSD IV	2	5,000						

Permitted

						Actual Situation Turbines Qty	Actual Situation Turbines Size	Heaters Qty	Heaters Size
	PSD II	~~3~~	36,000	1	100,000	3	36,000		
		2	5,000			2	5,000		
	PSD IV	2	5,000			2	5,000		
	TOTAL		128,000		100,000		128,000		

T = Turbine (MHP)
H = Heater (mm BTU/hr.)

Location	PSD Permit	Turbines Qty	Turbines Size	Heaters Qty	Heaters Size	Swap I Qty	Swap I Size	Swap II Qty	Swap II Size	III Qty	III Size	IV Qty	IV Size
GC-2	PSD I	2	32,500										
	PSD II	2	3,500	3	42.5	+T=1	7.5			-T=1	22,600		
		1	1,400	1	310.5								
		4	22,600	1	5.0								
	PSD IV	3	26,600*									-T=3	26,600
		3	7,500*										
		45,000	capacity										

Permitted Total						Actual Situation Turbine		Heater	
	PSD I	2	32,500			2	35,000		
	PSD II	1	1,400	3	42.5	2	2,500	3	33.5
		2	3,500	1	310.5	1	4,900	2	16.8
		1	7,500	1	5.0	1	35,000	1	30.0
		3	22,600			1	7,700	1	38.0
	PSD IV	3	7,500						
		45,000	capacity			3	7,770		
	TOTAL		216,200		443.0		117,600		202.1

* Total capacity attained from turbine(s) ranging from 5 to 7.5 MHP
* Total capacity attained from turbine(s) ranging from 22.6 to 36 MHP

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PSD Permit Tracking Report

Permitted

Location	PSD Permit	Turbines Qty	Turbines Size	Heaters Qty	Heaters Size	Swap IV Qty	Swap IV Size
FS-1	PSD II	2	5,000				
		3	36,000				
	PSD IV	1	5,000	1	125,000	-1H	125,000
		1	36,000			-1T	36,000

Permitted Total

			Actual Situation Turbines Qty	Actual Situation Turbines Size	Actual Situation Heaters Qty	Actual Situation Heaters Size
PSD II	2	5,000	2	5,000		
	3	36,000	2	36,000		
PSD IV	1	5,000				
TOTAL		123,000		82,000		

T = Turbine (MHP)
H = Heater (MMBTU/hr.)

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PSD Permit Tracking Report

Location	PSD Permit	Turbines Qty	Turbines Size	Heaters Qty	Heaters Size	Swap I Qty	Swap I Size	Swap IV Qty	Swap IV Size
IPE	H_2O Flood	5	16,000	2	50,000	+4T +1T + H	4,000 25,000 750,000 capacity	-1T	16,000
Permitted Total						**Actual Situation**			
						Qty	Size	Qty	Size
		4	16,000	2	50,000			2	50,000
		4	4,000			4	2,500	2	185,000
		1	25,000		750,000	2	29,100		
	TOTAL		105,000		850,000		68,200		470,000

T = Turbine (MHP)
H = Heater (mmBtu/hr.)

Location	PSD Permit	Turbine Qty	Turbine Size	Heaters Qty	Heaters Size	Swap I Qty	Swap I Size	Swap II Qty	Swap II Size	Swap IV Qty	Swap IV Size
GC-3	PSD I	2	17,000			-T1	17,000	-T1 +T2	17,000 5,000		
	PSD II	2	3,500	2	42.5	+T1	7,500*				
		1	1,400	1	5.0						
		4	22,600	1	310.5						
	PSD IV	1 60,000 capacity	7,500*							-T	60,000

Permitted Total						Actual Situation Turbine		Heater	
	PSD I	2	5,000			1	4,900		
	PSD II	1	1,400	2	42.5	2	35,000	5	33.5
		2	3,500	1	5.0	1	7,770		
		4	22,600	1	310.5				
		1	7,500						
	PSD IV	1	7,500			1	7,770		
	TOTAL		123,000		400.5		90,440		167.5

* Total capacities attained from turbines ranging from 5 to 7.5 MHP
* Capacity attained from turbines ranging from 22.6 to 36 MHP

Location	PSD Permit	Turbines Qty	Turbines Size	Heaters Qty	Heaters Size	Swap IV Qty	Swap IV Size
FS-3	PSD II	4	36,000				
		2	5,000				
	PSD IV	2	5,000	1	125,000	-1H	125,000

Permitted Total				Actual Situation Turbines Qty	Actual Situation Turbines Size	Heaters Qty	Heaters Size
	PSD II	4	36,000	3	36,000		
		2	5,000	2	5,000		
	PSD IV	2	5,000	2	5,000		
	TOTAL		164,000		128,000		

Location	PSD Permit	Turbines Qty	Turbines Size	Heaters Qty	Heaters Size	Swap I Qty	Swap I Size	Swap IV Qty	Swap IV Size
STP	H_2O Flood			3	110,000	+3H	100,000	+6H	120,000
				2	60,000			-3H	110,000
								-2H	60,000
								-3H	100,000
	PSD IV	8	4,000					-8T	4,000

Permitted Total

	Turbines Qty	Turbines Size
H_2O Flood	6	120,000
TOTAL		720,000

Actual Situation

Turbines Qty	Turbines Size	Heaters Qty	Heaters Size
		6	120,000
			720,000

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PSD Permit Tracking Report

Location	PSD Permit	Turbines Qty	Turbines Size	Heaters Qty	Heaters Size	Swap IV Qty	Swap IV Size
CCP	PSD I	3	25,000				
	PSD II	1	25,000	1	26,000	-1H	26,000
	PSD IV					+2T	36,000
						+2T	36,000
						+3T	36,000
						+3H	90,000

Permitted Total						Actual Situation Turbines Qty	Actual Situation Turbines Size	Heaters Qty	Heaters Size
	PSD II	1	25,000	3	90,000	1	25,000		
	PSD IV	2	36,000						
		2	36,000						
		3	36,000						
	TOTAL		252,000		270,000		25,000		

T = Turbine (MHP)
H = Heater (mm Btu/hr.)